DOCUMENT RESUME

ED 039 736 56c EM 008 069

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| TITLE | Should Educators Generate Specifications for the Purchase of Equipment? |
| INSTITUTION | Academy for Educational Development, Inc., Washington, D.C. |
| SPONS AGENCY | Office of Education (DHEW), Washington, D.C. Bureau of Research. |
| BUREAU NO | BR-8-0571 |
| PUB DATE | [70] |
| NOTE | 15p.; This is one of the support papers for "To Improve Learning; a Report to the President and the Congress of the United States by the Commission on Instructional Technology", ED 034 905 |
| EDRS PRICE | EDRS Price MF-$0.25 HC-$0.85 |
| DESCRIPTORS | Cost Effectiveness, Decision Making, *Educational Planning, *Educational Specifications, Equipment Standards, Instructional Technology |

ABSTRACT

Many educators believe that they should be able to decide what they need and issue functional specifications for the equipment they want to purchase. In order to maximize the cost effectiveness of a given technology, it may be better to have a constant interplay between people familiar with educational problems, educational research, hardware technologies, and production and development costs, so that it will be possible to make intelligent trade-offs among various alternative approaches. Educational users should also be represented on all appropriate industrial standardization committees and should agree to specify that all equipment they order must be in compliance with the standardization recommendations of these committees, unless there is some urgent educational reason for deviating. Government support of research would help to encourage companies to develop products without the necessity of having a guaranteed market against which they can write off their development costs. (JY)

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ED039736

# Should Educators Generate Specifications for the Purchase of Equipment?

by R. Louis Bright*

I have heard many educators express their dissatisfaction with the current educational hardware that is being "foisted on the schools by manufacturers whose only interest is to make a fast buck." They state their belief that the only way to straighten things out is to have educators decide what they really need and issue functional specifications for the equipment they want to purchase. The purpose of this paper is to examine this premise in more detail.

There are two major problems relevant to the introduction and acceptance of new forms of educational hardware. The first is: Is it appropriate for the educational function intended? This question breaks down into two important sub-parts: Does it perform a useful educational function? and; Is the cost reasonable for that function?

This requires that one consider all of the costs associated with the utilization of that hardware including: The amortization of the purchase price and installation cost, taking into account any changes in the professional to student ratio, requirements for additional no-professional employees, maintenance costs,

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materials costs, and space costs.

As to whether or not it performs the educational function should most appropiately be answered on a cost effectivness basis in which one compares the education effectiveness of the system using this hardware with that of other possible alternative costing the same amount. In other words, could one perform that educational function as well or better by hiring additional people, using other types of equipment, or by some other technique for the same dollars?

The second major question relevant to the introduction of new hardware is the "Chicken and Egg Problem." No one will buy a piece of equipment unless there is a large library of course material to go with it, and no one will invest in the development of special software until the machine is in wide use.

Unfortunately, these two questions are not independent; they are inexorably related by the fact that the cost of a piece of equipment depends upon the size of the production run, both because of the direct economy of high production and because the engineering development costs must be distributed across that production run.

Thus, the probability of obtaining a favorable answer to the first question (cost effectiveness) depends critically upon

the solution to the second.

I think that the most productive way of analyzing the efficacy of "educator developed specifications" is to see if they would ameliorate either of these problems.

The major consequence of these problems in the past has been to give us a line of educational equipment almost all of which was basically designed to serve some other purpose. I think the reasons for this are two fold. One, closely related to the question of this paper, is due to the fact that in many cases educators become familiar with and intrigued by the possibilities of equipment used for other purposes, for example, television and audio tape recorders. Television was clearly developed primarily for the home entertainment field, tape recorders were initially developed for military purposes and then put into production form for home entertainment. Having seen these devices in the home, many educators had the imagination to see applications for them in education and either used them without modification or asked suppliers if they would supply units altered in some relatively minor way. The other reason, of course, is related to the "Chicken and the Egg Problem" in that by simply making slight modifications on equipment whose development cost had been written off in other market areas, manufactures could introduce equipment at a much lower cost than if they had begun from scratch.

The results are, however, that very little of this equipment really makes much sense if one asks the first question: Is it appropriate; does it perform the function well, and does it do it at a cost which makes it competitive with the alternative ways of achieving the same function? The common error here is that in very few cases do people consider the total cost. For instance, with conventional audio-visual equipment (primarily modifications of motion picture camera's and projectors that were designed for the home entertainment field), most people pay attention only to the initial cost. They do not compute the tremendous cost of inventory, the cost of acquainting teachers with these materials, the professional time spent in previewing materials, or the maintenance costs, all of which are certainly real operating costs in any educational system.

One example of equipment that was specifically designed for educational use is the overhead projector, and I believe that a comprehensive analysis would show that its instructional cost effectiveness does compete very successfully with the alternative of a blackboard, particularly where teachers make extensive use of industrially prepared transparancies.

In writing specifications for hardware, it is only natural for educators to fall into the trap of only specifying those

things that they have seen in use, thereby perpetuating this use of equipment designed for something else. Few educators are really familiar with the physical science research and development programs which are continually extending the techniques that could conceivably be brought to bear on the solution of educational problems. Few educators are even familiar with the educational research which tries to define optimum conditions for learning. Again the tendency is to simply perpetuate present teaching techniques or minor alterations of them. Most educators have not had the experience necessary to estimate high volume production costs of equipment, nor are they sensitive to the fact that small differences in the design and specifications can make major differences in development and production costs.

One can give several examples from the rapidly developing art of computer aided instruction; e.g., it was early evident that an interface in which one simply had a pictorial and printed display and a key board by which the student could respond, was not adequate, particularly with very young children. It was necessary to have some type of non-alphanumeric manipulative input for the student. One very attractive solution is to use a light pen (using a technology developed for the military).

It is technically possible for a student to draw figures, letters, lines and so on upon a cathode-ray tube and have the computer receive and analyze this information. Unless one digs more deeply, it is not apparent that the ability to draw a line with a light pen costs about $600.00 in initial cost per student station and requires a much greater computer capacity than a $60.00 alternative in which the student uses the light pen to point to a fixed position on the screen and the computer detects where he is pointing. There is a very real question as to whether the ability to draw a line is worth ten times as much as the ability to point. Careful consideration of this situation seems to indicate that in almost all educational situations, the ability to point is an extremely useful function, but the additional ability to draw a line is seldom worth the cost.

Let me give a specific example of the use of alternative approaches. One of the reasons some educators were so enthusiastic about writing with a light pen was so that children could draw letters and have the computer check them for correctness. Although this is theoretically possible, it is both very difficult to define the tests that a computer must make to decide whether a letter is "correct" and still more complicated to have it indicate what was wrong, and, as has been pointed out, it

is espensive to provide this writing capability. Actually the educational objective is not really to have a computer judge whether the letter is correct or not, but rather to have the child decide whether it is correct or not. In other words, it is necessary for the child to discriminate between a wiggle that society considers to be an acceptable "A" and a somewhat similar wiggle that society will not generally accept. This discrimination can be elegantly taught by displaying sets of related wiggles on the screen and asking the student to point to the best "A". Experiments have been conducted that show that this latter (and much cheaper) technique is much more effective in teaching children how to make letters than the former.

I again want to emphasize that I do not think that it would be obvious to most educators that these two, apparently only slightly different functions, (writing and pointing) would have more than an order of magnitude difference in cost. Still other examples from the same field can be given. For example, it is desirable to have a large number of pictorial displays available at random in a very short access time from a large store of pictures. Careful analysis seems to indicate that the cost of providing even quite a detailed black and white line drawings at

a given access time from a given size store, will be an order of magnitude cheaper than providing grey tone drawings and perhaps still another magnitude cheaper than color continuous tone pictures. The educational problem must be faced as to what kind of educational situation is a colored grey tone or picture significantly more functional than a line drawing. If one were to look at the beautiful line drawings in a medical anatomy text, it is apparent that this question is a real one. No one, to my knowledge, has yet worked on this problem of comparing the cost effectiveness of computer-produced line drawings on a cathade-ray tube with that of color slides on a computer-controlled projector, where again total cost, including initial cost, maintenance, library and so on, are considered. Even in the more traditional audio-visual fields there are many questions that the educator has generally chosen to ignore. For example, the total cost of an audio-visual system is dominated by the inventory cost and not by the initial cost of the equipment. If one looks at this, one finds, of course, that the inventory cost of motion, either whether provided by video tape or motion pictures, is at least an order of magnitude, and probably two orders of magnitude, more expensive than storing an equivalent amount of

course material on slides, film strips or other still picture techniques. Is this difference in one or two orders of magnitude in cost really reflected in a difference in educational effectiveness? In some cases such as the study of the life of primitive tribes in Africa or in viewing a Shakespearean drama, I am sure that motion is very desirable. However, what few experiments have been done indicate that in very few traditional subject areas does motion appear to have any advantage significant. In fact, in many cases it appears to be distracting. Certainly the cost of the preparation of the materials are also significantly different. In many cases, if the amount of money spent on a motion picture production had been spent on a careful analysis of the educational objectives and the production of a series of well prepared slides, the student learning would have been improved.

In summary, I don't think that the solution to the first problem, cost effectiveness, is likely to be solved by educator developed specifications. Rather it is very necessary that there be a constant interplay between people familiar with educational problems, educational research, hardware technologies and production and development costs so that it will be possible to make intelligent trade-offs among various alternative approaches.

The second part of the analysis is to decide whether educator developed specifications assist in the "Chicken and the Egg Problem." I think an interesting example can be given here: Last year one of the foundations felt that there was a real need for a low cost projector having certain characteristics and estimated there would likely be a market for about 10,000 such units. They approached a major audio-visual company and asked them if they could make a projector that would sell at a specified cost. The answer was, "At that number of units, yes, we can. Will you guarantee to reimburse us for the unrecovered development costs if our market does not reach your estimate within a two year interval?" The answer that the foundation was forced to give was, "No, it could not guarantee the development costs." The company did not produce the equipment.

As we look in more detail at educator developed specifications, it is immediately apparent that they are likely to fall into two distinct categories. One is where the educator wishes to conduct research on learning and wants a particular type of envionment or presentation. The second is where the educator is planning to purchase the equipment for regular operation use in a school. The economic constraints on these two are clearly very different. For example, many researchers are able to specify the type of

experimental functions they would like to have. With our present technologies, the hardware supplier can supply almost any conceivable type of function or environment if the customer is willing and able to pay for it. In many research projects, the researcher is amply endowed by Federal or foundation funds and orders it, and the hardware companies produce it. In some such cases it is not the large volume manufacturer that would respond, but in nearly all such cases you would find at least a few speciality houses that would be willing to design and build the equipment.

For the other type of requirement, the operational requirement, the size of the order is seldom large enough to justify the expenditure of any significant amount of development funds by the supplier. Or, putting it in another way, the development costs amortized over the number of units requested would result in a higher unit cost than the customer could justify. The only way in which educator specifications seem to assist in the "Chicken and the Egg Problem" is in the case where the customer is large enough to control a sufficient number of units to really justify the investment of significant development dollars. This could conceivably occur if some of the major states purchased hardware for all of the school systems within that state in a single order.

I believe another serious situation would result if this was a common practice. If each of the major states came up with its own set of specifications and suppliers responded to these, it is unlikely that there would be any standardization between the states. Equipment and materials developed in one state would not be interchangable with that used in another, nor is it likely that there would be more than one supplier competing for second round orders. The problem becomes even more serious if one is concerned about driving the cost down to levels which can be attained by really mass production, i.e. if one is concerned about actual unit production costs as contrasted to simply the distribution of developmental costs. Here the number of units involved must be extremely large in order to realize the economies which are possible through automatic production. Another important factor in the overall situation involves the maintenance of competition. In the long run, a hardware system is likely to be much lower in cost if there are several manufacturers supplying the same type of function. This is closely related to the establishment of standards so that tapes, films, and other types of software programs developed for one manufacturer's machine will run on that of another without modification.

This emphasizes that there are dangers inherent in not

specifying what you need. There is at the present time very little incentive for manufacturers to standardize their products. In fact, the major suppliers intentionally try to avoid standardization so that there will be less likelihood of their encountering competition on second round orders. I believe that the only way this problem can be solved and the resulting economies achieved is for the educational community to issue specifications in the following sense: Educational users should be represented on all appropriate industrial standardization committees and should agree to specify that all equipments they order must be in compliance with the standardization recommendations of those committees unless there is some urgent educational reason for deviating.

That route also has its dangers in that it tends to standardize on existing techniques and, hence, discourages the introduction of new and different types of hardware. In order to really solve the "Chicken and the Egg Problem", I believe that it is essential that the Federal government or major states provide development support directly to manufacturers of both equipment and software in order to encourage these companies to develop and introduce new products without the necessity of having a guaranteed market against which they can write off their development costs. This is certainly not a new concept. It has

been applied to the construction of railroads, the subsidization of air mail, the research and development of sea water desalination and pollution control, to say nothing of defense or space. If this technique has been successful in bringing new products to these other areas of social need, why should not the same technique be applied to education? Many people react negatively to this concept in that they feel that it would give the company, who has received the development funds, an unfair competition. This may be the case for a short time; but if there is a requirement that the developments be licensed to other companies at a reasonable fee, and if all companies have an equal chance to apply for such development funds, it seems to me that there has been a competitive situation established.

In order to obtain the social benefits resulting from the educational utilization of the latest technologies, such support programs should not be limited to competitive bids against specific specifications but should also provide companies that have invested much of their own funds on research the opportunity to present attractive ideas in the hope of getting sole source support. This is not discrimination or favoritism if all companies have this same opportunity.

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The fundamental question should not be whether it gives a company a momentary advantage but rather whether it is advantageous to society that such a product be developed and made available. Certainly, particular railroad companies were given competitive advantages in certain areas as were particular air lines, but the fundamental question was asked, "Is it of benefit to the society to have these geographical regions accessible?" The benefits to society are obvious.

I believe that another consequence of providing development support will be similar to that existing in other technical areas. If companies knew that there were major governmental development funds available to support imaginitive and unsolicited programs relating to education, they would very quickly within their own houses assemble very impressive teams of educators, psychologists and hardware specialists that could continuously interact in the evaluation of various techniques, so as to supply an answer to the first question, "Is the function appropriate?" This would be particularly true if the reviewing agencies in deciding which proposals to support made their selection primarily on the basis of "does the investigation proposed likely lead to an attractive cost effectiveness solution?"